THESIS/
REPORT

GUTIERREZ, R.J

INFLUENCE OF WEATHER ON MEXICAN SPOTTED OWLS

GUTIERREZ, R.J.

Library

INFLUENCE OF WEATHER ON MEXICAN SPOTTED OWLS

Submitted
March 2000

CONTRACTOR
Humboldt State University Foundation
Humboldt State University
Arcata, CA 95521

Principal Investigator
R.J. Gutiérrez
Department of Wildlife
Humboldt State University
Arcata, CA 95521

Project Leader
Christopher A. May
Department of Wildlife
Humboldt State University
Arcata, CA 95521

Assistant Project Leader
Mylea Petersburg
Department of Wildlife
Humboldt State University
Arcata, CA 95521

Contract No. RMRS-98073-CA

ABSTRACT

We examined the relationship of personnel effects (survey effort, observer experience, and presence of a project leader) on Mexican spotted owl recapture rates. Recapture rates generally were above 90% but there was considerable uncertainty regarding the influence of personnel on these rates. Recapture rates on the CSA were best explained by a quadratic time trend and no competing models included personnel effects. Recapture rates on the GSA were best explained by a linear time trend but competing models included survey effort. When the study areas were modeled jointly, survey effort best explained recapture rates but non-personnel and personnel effects were equally represented in the competing models. There was limited evidence that the presence of a project leader increased recapture rates whereas observer experience was not an important factor explaining recapture rates on either study area.

TABLE OF CONTENTS

	Page
LIST OF TABLES	iv
LIST OF FIGURES	v
INTRODUCTION	1
METHODS	1
RESULTS	3
Model Description	3
Model Uncertainty	6
DISCUSSION	9
ACKNOWLEDGMENTS	14
LITERATURE CITED	14
APPENDIX	15

LIST OF TABLES

Table		Page
1	Results of effects of personnel for the Coconino Study Area (CSA), central Arizona, and for the Gila Study Area (GSA), west-central New Mexico	5
2	Sum of Akaike weights for recapture rate parameters for the Coconino Study Area (CSA), central Arizona, and for the Gila Study Area (GSA), west-central New Mexico, 1991-1998. Sums of weights were only calculated for models within the 95% confidence set presented in Table 1	9
3	Recapture estimates for non-personnel and personnel effects models using model averaging for the Coconino Study Area (CSA), central Arizona, and for the Gila Study Area (GSA), west-central New Mexico, 1991-1998. Models used for averaging were only those presented in Table 1 . . .	11

LIST OF FIGURES

Figure — Page

1 Estimated time trends in recapture rates for the Coconino Study Area (CSA), central Arizona, and the Gila Study Area (GSA), west-central New Mexico. Estimates for recapture rates taken from model $\{\phi_{At}, p_{(T+TT)}\}$ for the CSA and model $\{\phi_{Aa2+t}, p_{T}\}$ for the GSA 16

2 Recapture rate as a function of "walk-in" survey effort on the Coconino Study Area (CSA), central Arizona, and the Gila Study Area (GSA), west-central New Mexico. Estimates for recapture rates taken from the combined study area model $\{\phi_{Ag*t}, p_{Ew}\}$ 16

INTRODUCTION

In this supplement to the 1998 annual report we examine the relationship of survey effort, observer experience, and presence of a project leader (hereafter collectively referred to as "personnel effects") on recapture rates for Mexican spotted owls. The annual report contains details of field methods and statistical procedures used for the analysis of personnel effects.

Field work is performed by project leaders and research assistants. Project leaders are long-term employees who supervise seasonal research assistants, set priorities in consultation with the Principal Investigator (PI), and are responsible, along with the PI, for maintaining standardized, high-quality data collection. They provide institutional consistency to long-term study of owls. Ideally, one project leader should be present on each of the two study areas (one in Arizona, one in New Mexico). Research assistants are seasonal employees who survey, monitor, capture, and band spotted owls during the five month field season under the direct supervision of the project leaders.

METHODS

During the course of this study, funding has fluctuated dramatically. This resulted in fluctuations of field personnel and project leaders. Therefore, we modeled the effects of walk-

in survey effort (E_w), combined walk-in and nighttime survey efforts (E_b), observer experience (C), and presence of a project leader during the field season (PL) on recapture rates. With the exception of the PL effect, we treated the personnel effects as annual group covariates. Survey effort was defined as total person-hours spent conducting surveys (walk-in or nighttime) during a given season (e.g., 2 persons x 2.5 hour walk-in = 5 person-hours). The effect of field observer experience on recapture rates was defined as the number of field seasons the observers within each year had worked with spotted owls (e.g. 4 observers; 2 with 1 year experience, 2 with no experience = 2 observer-seasons).

The presence of a project leader was modeled as a dichotomous variable (0=no, 1=yes) only when study areas were combined. The binomial (present/absent) could have been confounded with other variables both biological (e.g., birds are easier to resight when nesting) and non-biological (e.g., recapture rates may fluctuate with survey effort). Therefore, we treated project leader loss as an interrupted time series with a study area effect. We used the CSA as the control (a project leader has always been present) and the GSA as the treatment (PL loss in 1996 and 1997) and forced the study areas to have recapture rates vary with the same time trend. This assumes that the study areas vary similarly over time, but that an added

change in recapture rates occurs when a project leader is absent. We felt this would provide a means of estimating the effects that could be attributed to PL beyond what could be explained by the confounding factors common to both study areas.

We first modeled the effects of age, sex, and time on survival and recapture rates of territorial owls. Model results in the annual report were based on both territorial and non-territorial (i.e., juvenile) owls. However, since we were primarily interested in recapture rates for territorial birds, we removed non-territorial birds from the data set. In addition, we felt inclusion of non-territorial birds would introduce additional "noise" into the modeling, thereby making inferences about personnel covariates more difficult. The order of the top models in the annual report did not change after non-territorial owls were removed. The top age, sex, and time models were then further constrained using the personnel covariates.

RESULTS

Model Description

For the CSA, model $\{\phi_{At}, p_{(T+TT)}\}$ best fit the data based on $QAIC_c$ values; however, model $\{\phi_{At}, p_{Aa2+(T+TT)}\}$ was about as likely based on AIC_c weights (Table 1). The only difference between these two models was that in the first model recapture rates were identical for all age classes whereas in the second subadults had

higher recapture rates than adults. However, the subadult group effect was not estimated (i.e., was forced to a value of 1) in these models due to sparse data in some years. Both models indicated a quadratic trend in recapture rates, with the low point occurring in 1995 (Fig. 1). One of these models, $\{\phi_{At}, p_{Aa2+(T+TT)}\}$, had been the best model before juveniles were removed and personnel effects were included in the analysis (refer to Table 9 of the annual report). No models containing personnel effects were within 2 QAICc points of the top model. Based on AIC_c weights, the best model was 3.3 times more likely than the highest model containing combined walk-in and nighttime survey effort, 4.8 times more likely than the highest model containing walk-in survey effort, and 9.3 times more likely than the highest model containing observer experience. Therefore, based on QAICc distance from the top model and AIC_c weights, personnel effects did not explain the CSA data well.

For the GSA, model $\{\phi_{Aa2+t}, p_T\}$ best fit the data based on $QAIC_c$ values and was more than twice as likely as the closest competing model based on AIC_c weights (Table 1). This top model indicated a decreasing linear time trend in recapture rates (Fig. 1). There were five competing models (i.e., within 2 AIC of the top model), two of which contained personnel effects. Recapture rates were explained by walk-in survey effort in one model and by combined walk-in and nighttime survey efforts in the other model.

Table 1. Results of personnel effects modeling for the Coconino Study Area (CSA), central Arizona, and for the Gila Study Area (GSA), west-central New Mexico.[a]

Model[b]	K[c]	$QAIC_c$	$\Delta QAICc_i$[d]	w_i
CSA				
$\{\phi_{At}, p_{(T+TT)}\}$	10	419.22	0	0.271
$\{\phi_{At}, p_{Aa2+(T+TT)}\}$	11	419.66	0.44	0.217
$\{\phi_{Aa2+t}, p_{Aa2+(T+TT)}\}$	12	421.07	1.85	0.108
$\{\phi_{s+t}, p_{Aa2+(T+TT)}\}$	12	421.50	2.28	0.087
$\{\phi_{At}, p_{Eb}\}$	9	421.63	2.41	0.081
$\{\phi_{At}, p_{Aa2+Eb}\}$	10	422.34	3.12	0.057
$\{\phi_{At}, p_{Ew}\}$	9	422.38	3.16	0.056
$\{\phi_{At}, p_{Aa2+Ew}\}$	10	423.14	3.92	0.038
$\{\phi_{At}, p_{Eb+C}\}$	10	423.67	4.45	0.029
$\{\phi_{At}, p_{Ew+C}\}$	10	424.45	5.23	0.020
GSA				
$\{\phi_{Aa2+t}, p_{T}\}$	10	370.34	0	0.294
$\{\phi_{Aa2+t}, p_{Ew}\}$	10	371.76	1.42	0.145
$\{\phi_{Aa2+t}, p_{Eb}\}$	10	371.97	1.63	0.130
$\{\phi_{.}, p_{T}\}$	3	372.19	1.85	0.116
$\{\phi_{Aa2+t}, p_{Aa2+T}\}$	11	372.24	1.90	0.113
$\{\phi_{Aa2+t}, p_{T+TT}\}$	11	372.44	2.10	0.103
$\{\phi_{Aa2+t}, p_{Ew+C}\}$	11	373.69	3.35	0.055
Both Study Areas				
$\{\phi_{Ag*t}, p_{Ew}\}$	16	712.91	0	0.172
$\{\phi_{Ag*t}, p_{GSA(T),CSA(T+TT)}\}$	19	712.96	0.05	0.168
$\{\phi_{Ag*t}, p_{Eb}\}$	16	713.50	0.59	0.128
$\{\phi_{Ag*t}, p_{T+TT}\}$	17	713.65	0.74	0.119
$\{\phi_{Ag*t}, p_{(T+TT)+PL}\}$	18	714.53	1.62	0.077
$\{\phi_{Ag*t}, p_{g*Ew}\}$	17	715.01	2.10	0.060
$\{\phi_{s+(Ag*t)}, p_{GSA(T),CSA(T+TT)}\}$	20	715.03	2.12	0.060
$\{\phi_{Ag*t}, p_{g*Eb}\}$	17	715.04	2.13	0.059
$\{\phi_{Ag*t}, p_{CSA+GSA(T+TT)}\}$	18	715.22	2.31	0.054
$\{\phi_{Ag*t}, p_{T}\}$	16	715.26	2.35	0.053

[a] Each section of the table contains the 95% confidence set of models based on AIC weights (i.e., the sum of the AIC weights in each section is 0.95). The analysis included additional models which are not presented here because they are not likely to explain the data well.

[b] Refer to the appendix for explanations of model notation.

[c] Number of parameters.

[d] Difference in AIC value between each model and the "best" model.

Based on AIC_c weights, the top model was 5.4 times more likely than highest model containing observer experience.

For both study areas combined, model $\{\phi_{Ag*t}, p_{Ew}\}$ was ranked best based on QAICc values; however, model $\{\phi_{Ag*t}, p_{GSA(T),CSA(T+T^2)}\}$ was essentially equal based on both QAICc values and AIC weights
Based on AIC_c weights, the top model was 5.4 times more likely than highest model containing observer experience.

For both study areas combined, model $\{\phi_{Ag*t}, p_{Ew}\}$ was ranked best based on QAICc values; however, model $\{\phi_{Ag*t}, p_{GSA(T),CSA(T+T^2)}\}$ was(Table 1). The former model indicated recapture rates were explained by walk-in survey effort (Fig. 2). The latter indicated that GSA recapture rates were best explained by a decreasing linear time trend while CSA recapture rates were best explained by a quadratic time trend (Fig. 1). There were three other competing models. Recapture rates in these models were explained by 1) combined walk-in and nighttime survey efforts, 2) a quadratic time trend, and 3) an additive combination of a quadratic time trend and the presence of a project leader. The top model was 86 times more likely than the highest model containing the observer experience variable.

Model Uncertainty

Several methods exist to quantify model selection uncertainty. Among these are 95% confidence sets of models, AIC weights, and the sum of AIC weights for all models containing a

variable of interest (Burnham and Anderson 1998). Each of these methods is discussed below.

A 95% confidence set of models is obtained by ranking the models in ascending order by QAIC values and summing the AIC weights until a total of 0.95 is reached. Theoretically, the resulting set of models will contain the best model for 95% of the independent samples collected from a given population and analyzed with the same set of models. For this analysis, the number of models in the 95% confidence sets ranged from 7 to 10 and included both personnel and non-personnel effects (Table 1). Thus, the order of the models presented in Table 1 likely would change if an independent sample was drawn from same population. Given our goal of assessing the effect of personnel covariates on recapture rates, this method of quantifying selection uncertainty provided little insight.

AIC weight can be considered the relative likelihood of a model being the best model among the models tested given the data. Under this method of quantification, personnel effects had relatively little support for the CSA when modeled alone (Table 1). The highest-ranking personnel effects model was 3.3 times less likely than the highest-ranking non-personnel effects model and was preceded by four non-personnel effects models. For the GSA, the importance of personnel effects was less clear (Table 1). The highest-ranking personnel effects model ranked second

and was half as likely as the top model, which indicated a negative linear time trend (i.e., non-personnel effect) in recapture rates. For both study areas combined, a personnel effects model was ranked highest but was essentially as likely as the highest model without personnel effects (Table 1).

The sum of AIC weights for all models containing a variable of interest can provide further insight into the importance of particular variables. If a variable is present in several models but none of the models is ranked best, there is strong evidence that the variable is important in explaining part of the data. For the CSA, summed AIC weights (Σw_i) indicated a quadratic time effect (Σw_i=0.683) for recapture rates best explained the data (Table 2). An age effect also had relatively strong support (Σw_i=0.507) while personnel effects had relatively little support (Σw_i=0.281 for survey effort). For the GSA, a linear time trend was supported best (Σw_i=0.523) while personnel effects had relatively little support (Σw_i=0.330 for survey effort). Therefore, when considering the two study areas separately, models including non-personnel variables were most likely to explain recapture rates. When the study areas were combined, a quadratic time trend (Σw_i=0.478) and survey effort (Σw_i=0.419) explained recapture rates equally well.

Table 2. Sum of Akaike weights for recapture rate parameters for the Coconino Study Area (CSA), central Arizona, and for the Gila Study Area (GSA), west-central New Mexico, 1991-1998. Sums of weights were only calculated for models within the 95% confidence set presented in Table 1.

Area	Effects[a]					
	Non-personnel			Personnel		
	Aa2	T	T+TT	PL[b]	(Ew,Eb)	C
CSA	0.507	0	0.683	--	0.281	0.049
GSA	0.113	0.523	0.103	--	0.330	0.055
Both Study Areas	0	0.281	0.478	0.077	0.419	0

[a] Refer to the appendix for explanations of effect notation.

[b] The PL effect was modeled only for both study areas combined.

DISCUSSION

This analysis revealed considerable model selection uncertainty regarding the impact of personnel effects on recapture rates. No single model was strongly supported by the data, possibly due to the small sample size and short duration of the study. In addition, there was a change from an experienced to an inexperienced PL on the GSA during the study, as well as ancillary PL guidance to the GSA from the CSA to help compensate for the lack of a PL. Both of these latter situations were confounding influences which could not be explicitly modeled. The uncertainty also could be due to a real lack of any personnel effects. Overall, personnel effects were not very useful in explaining the observed data; effort played a role as evidenced by the competing models, but ultimately recapture rate was best

explained by time effects (Table 2). Recapture rates generally were >90% regardless of the effects considered (Table 3).

When modeling the study areas separately, evidence based on QAIC values and AIC weights supported models without personnel effects on recapture rates. Recapture rates were best explained by time effects. However, this conclusion was less apparent when using other model selection criteria (e.g., 95% confidence sets).

When modeling the study areas jointly, personnel and non-personnel effects explained the recapture data equally well. All the competing models had very low AIC weights, suggesting none was explaining the data better than the others. We modeled the study areas jointly to assess the effect of project leader presence on recapture rates. However, when estimating recapture rates, we believe modeling the study areas separately is more meaningful due to differences in topography, habitat, historical effort, and personnel fluctuations.

Poor estimation of the 1998 recapture rates could be an important factor affecting the results of this analysis. Parameter estimates for a given year are derived from data collected during both the previous and following years. Therefore, the 1998 estimates either are not precise (i.e., reliable) or are not estimated at all. We suspect the negative trend in GSA recapture rates would not be as strongly supported if the 1998 parameter was better estimated (i.e., if the 1999

Table 3. Model averaged recapture estimates for non-personnel and personnel effects models for the Coconino Study Area (CSA), central Arizona, and for the Gila Study Area (GSA), west-central New Mexico, 1991-1998. Models used for averaging were only those presented in Table 1.

Area	Effect			
	Non-personnel		Personnel	
	$\hat{p}$	SE	$\hat{p}$	SE
CSA	0.932 (0.822, 0.969)	0.028	0.923 (0.850, 0.961)	0.027
GSA	0.888 (0.802, 0.939)	0.034	0.902 (0.818, 0.947)	0.031
Combined				
CSA	0.925 (0.804, 0.969)	0.035	0.925 (0.858, 0.962)	0.025
GSA	0.900 (0.796, 0.952)	0.038	0.902 (0.830, 0.945)	0.028

data were included in the analysis). This suspicion is based on 1) an observed rise in the empirically calculated recapture rate for 1998, and 2) increased funding in 1998 that supported an assistant project leader on the GSA. Therefore, additional years of data could change the results of this analysis.

The differences in time trends supported by the data on the two study areas probably is due to weather effects (Seamans et al. In prep.). On the CSA, the quadratic time trend in recapture rates appears correlated with drought conditions observed since the study began, suggesting the effect of monsoon/annual rainfall is important. On the GSA, the negative linear time trend in recapture rates would likely change with additional years of data

(see above). The lack of an observed effect for the GSA could be due to a weaker relationship between precipitation and owl demographics on the GSA, or a buffering effect of habitat.

Observer experience did not affect model selection for either study area. We have a rigorous evaluation process for potential employees. Generally, applicants possess a degree in wildlife, natural resources, or a related field and have established a commitment to science through previous work experience. Given our hiring standards and the extensive training we provide, prior experience specific to spotted owls is not necessary to accomplish our goals. However, without sufficient training and qualifications, we likely would be less successful. In addition, the spotted owls' docile nature allows inexperienced personnel to capture/resight birds with relative ease. The primary reason we are able to hire quality personnel is because we can provide a semi-competitive salary; lower funding would negate this ability. In fact, based on our experience during years when funding is decreased or committed late, the quality of personnel suffers; we maintain quality data collection through more intensive supervision of the field crew and compensate further by an increased workload by the project leader, graduate students, and some research assistants.

Models including walk-in survey effort were competitive for the GSA. This relationship is intuitive to an extent; if an

individual owl is hard to find or uncooperative, the crew spends the time necessary to capture/resight it. High recapture probabilities are critical for unbiased survival estimates and high power to detect changes due to the relatively small initial sample size for our studied populations. Therefore, we believe the effort expended toward increasing recapture rates was justified and should be sustained. The reason for the lack of such a relationship on the CSA is unclear, but may be due to more cooperative owls, more experienced crews, or a better explanatory factor (e.g., time trend).

The presence of a project leader (PL) was not an important factor in model selection for the study areas when combined. The GSA lacked a PL during 1996 and 1997. The lack of PL importance in explaining the data could be due to the lack of an effect of PL presence during the field season. However, the PI and PLs from other study areas visited the GSA regularly (at least once a month) during both seasons and helped capture/resight >35% of the birds each year (unpubl. data). These birds generally were uncooperative (i.e., recapture rates would have been significantly reduced without visiting researchers). We stress the importance of permanent supervisory personnel to maintain quality data collection, organize field tasks, and provide a degree of continuity during the project.

ACKNOWLEDGMENTS

We thank A.B. Franklin and M.E. Seamans for technical assistance. This research was supported by funds provided by the Rocky Mountain Research Station, Forest Service, U.S. Department of Agriculture; U.S. Forest Service Region 3; and the Arizona Game & Fish Department. We would also like to thank Jim Hamby and the rest of the HSU Foundation staff for auxiliary support.

LITERATURE CITED

Burnham, K.P., and D.R. Anderson. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, Inc., NY, NY.

Seamans, M.E., R.J. Gutiérrez, and C.A. May. In prep. Weather related variability in survival and reproduction of two Mexican Spotted owl populations.

Appendix. Model notation used for survival and recapture rates of Mexican spotted owls.

Effect	Description
Basic Survival and Recapture	
ϕ	survival probability between year *i* and *i+1*.
p	recapture probability for year *i*.
A	non-juveniles ($\geq$ 1 year old).
an	categorical age (a) effect for n age classes; for survival or recapture.
CSA	effect specific to the Coconino Study Area, Arizona.
GSA	effect specific to the Gila Study Area, New Mexico.
g	group (i.e., study area).
s	sex effect.
t	categorical time variation.
T	linear time trend.
T+TT	quadratic time trend.
+	additive effect between terms.
x	interaction between terms.
.	constant.
Personnel Effects	
C	crew experience.
E_b	combined walk-in and nighttime survey effort.
E_w	walk-in survey effort.
PL	project leader.

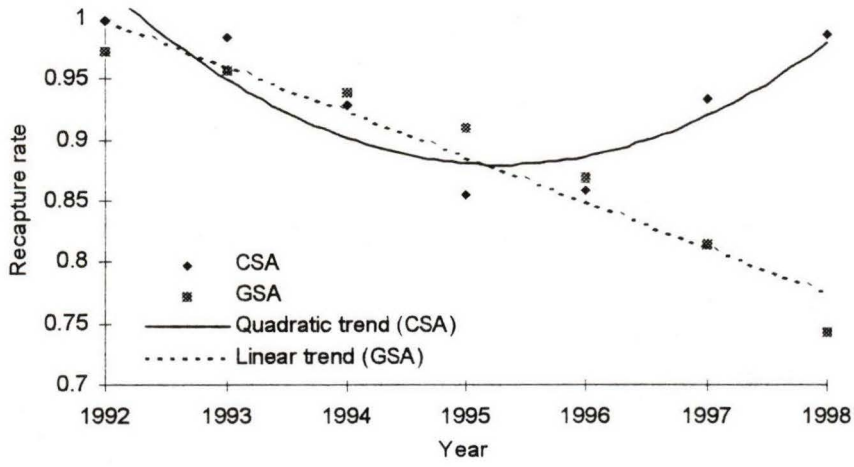

Figure 1. Estimated time trends in recapture rates for the Coconino Study Area (CSA), central Arizona, and the Gila Study Area (GSA), west-central New Mexico. Estimates for recapture rates taken from model $\{\phi_{At}, p_{(T+TT)}\}$ for the CSA and model $\{\phi_{Aa2+t}, p_{T}\}$ for the GSA.

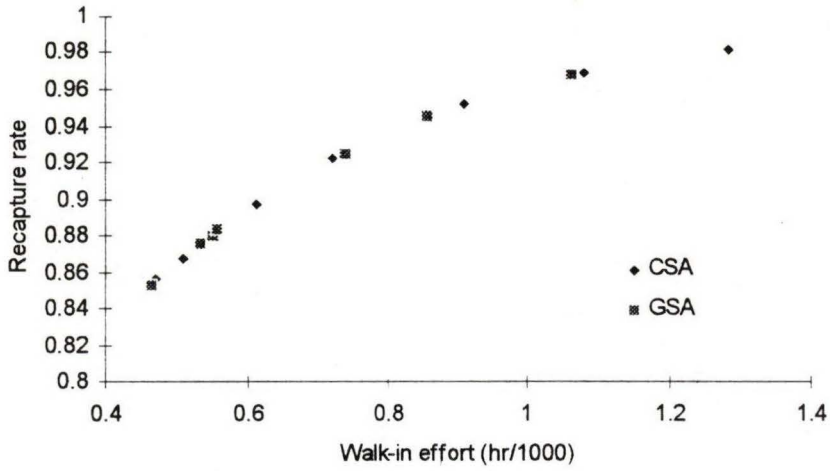

Figure 2. Recapture rate as a function of walk-in survey effort on the Coconino Study Area (CSA), central Arizona, and the Gila Study Area (GSA), west-central New Mexico. Estimates for recapture rates taken from the combined study area model $\{\phi_{Ag*t}, p_{Ew}\}$.